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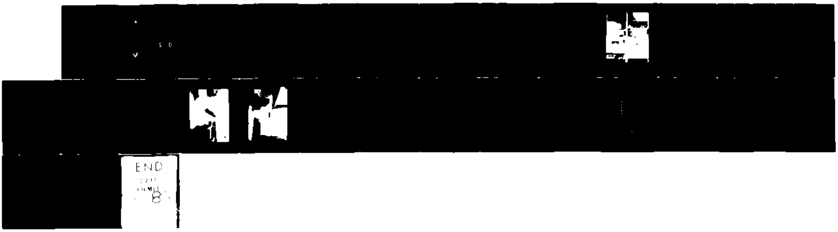

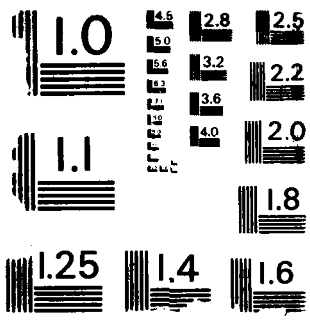
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TECHNICAL REPORT RD-DE-89-1

DESIGN OF A COMMAND, COMMUNICATIONS, AND CONTROL VAN (SURROGATE)

J. Darryl Holder
Jerome Fishback
Directed Energy Directorate
Research, Development, and
Engineering Center

MARCH 1989

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This report describes the design, construction, and checkout of a radio and telephone multi-mode communications hub. This unit is to serve as a surrogate for a command, control, and communications van which is to be used in support of a special series of testing at a remote site. This unit is assembled in a military four-wheel van and has a crew of a commander and three operators. Radio communications monitoring can be performed in all popular modes of transmission from 50 KHz to 2 GHz and transmission can be performed on selected frequencies in the 40-meter, 6-meter, and 2-meter bands. Both voice and digital (Teletype, packet, facsimile, etc.) communications are supported.

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I. OBJECTIVE

A requirement exists for a command, communications, and control (C-Cube) van in connection with planned testing at a remote field site. A standard Army C-Cube van is not available for supporting this effort, so the decision was made to assemble a work-alike or surrogate system. The effort described herein is that involved in the design and development of a surrogate C-Cube van from commercially available and military components.

II. METHOD

Since the functional portion of a C-Cube van is primarily a communications hub of multiple modes, a basic design was developed that would incorporate wired voice telephone, multi-station intercom, and broad radio-frequency (RF) spectrum voice and data radio systems with a local storage and routing intelligence aided by a microcomputer. The basic function of this system would be to enable communications to originate at any point and be routed to any other point in a network which has suitable hardware for its reception. The primary operator, with the aid of the computer and appropriate communications software, would enable this routing while maintaining a log of all communications which originate at, terminate at, or pass through this system. Conceptually, the system may be broken down into subsystems and components. The subsystems are: (1) physical structure, (2) radio subsystem, (3) internal communications, (4) wired telephone installation, (5) communications management subsystem, and (6) power subsystem. The following section describes these subsystems and their components in detail.

III. SUBSYSTEMS DESCRIPTION

A. Physical Structure

The C-Cube van is assembled in a military four-wheel, pintle-towed trailer. This trailer has a full metal shell and has been used in the past for field-environment work with high-technology equipment installations. The internal dimensions are 19 feet 5 inches long, by 7 feet 4 inches wide, with a floor to ceiling height of 6 feet 3 inches. The trailer is fitted with a reversible-cycle heat pump which is capable of maintaining usable working conditions in all but the very extremes of hot and cold climatic conditions. The roof of the trailer is fitted with a gridded walking surface which eased the installation, adjustment, and maintenance of the required antennas. Some repair, refit, and modification work was done in order to accommodate the installation of the required equipment. Some of these items were the sealing of unnecessary ports, providing for feed-through of the required antenna and telephone connections, and providing for the mounting of the radio and computer equipment.

B. Radio Subsystem

This subsystem is more than just radio-frequency reception and transmission devices. There is a mixture of receivers, transceivers, terminal node controllers (TNC) for digital, Teletype, and facsimile transmissions, and a radio terminal box which interfaces voice and data traffic to and from other modes of communication. Figure 1 shows a block diagram of this subsystem. In this figure, the area enclosed within the dashed outline is contained within the Radio Rack. Figure 2 is a photograph of the face of this which is a surplus double-bay computer cabinet with built-in power control and ventilation systems. In the photo of Figure 2, the top left unit is a PRC-77-77GY military transceiver (Unit 3), the second unit down is an R-1420/URR military receiver (Unit 7), the third unit is a Kenwood TM-221A transceiver (Unit 2). Mounted on a single panel below Unit 2 are the digital data devices. At the top is a rotary switch box (Data Switch) which connects one of three channels of digital data to the microcomputer. Below the Data Switch are mounted three AEA PK-232 terminal node controllers which act as digital interfaces between the radio receivers/transceivers and the microcomputer. At the bottom of the left bay is a DC power supply which provides the 28 volts required by the intercom units. At the top of the right bay of the Radio Rack is mounted a telemetry receiver which was not implemented into the system. The second unit in the right bay is a Kenwood TS-140S transceiver (Unit 1). The third unit down is an Icom R-7000 receiver (Unit 5). The fourth unit is a Yeasu FRG-8800 receiver (Unit 6). In the bottom panel of the right bay are two Kenwood PS-430 DC power supplies which provide the 13.8 volts DC required by Units 1, 2, and 3 and the three TNC's. Not shown in the photo is the power control switch at the top right of the cabinet and the Radio Terminal Box, power conditioning units, and the power/ventilation system which are enclosed within the cabinet. Expansion capability exists both in the electrical system and in space in the Radio Rack for the installation of another transceiver (Unit 4) and another receiver (Unit 8).

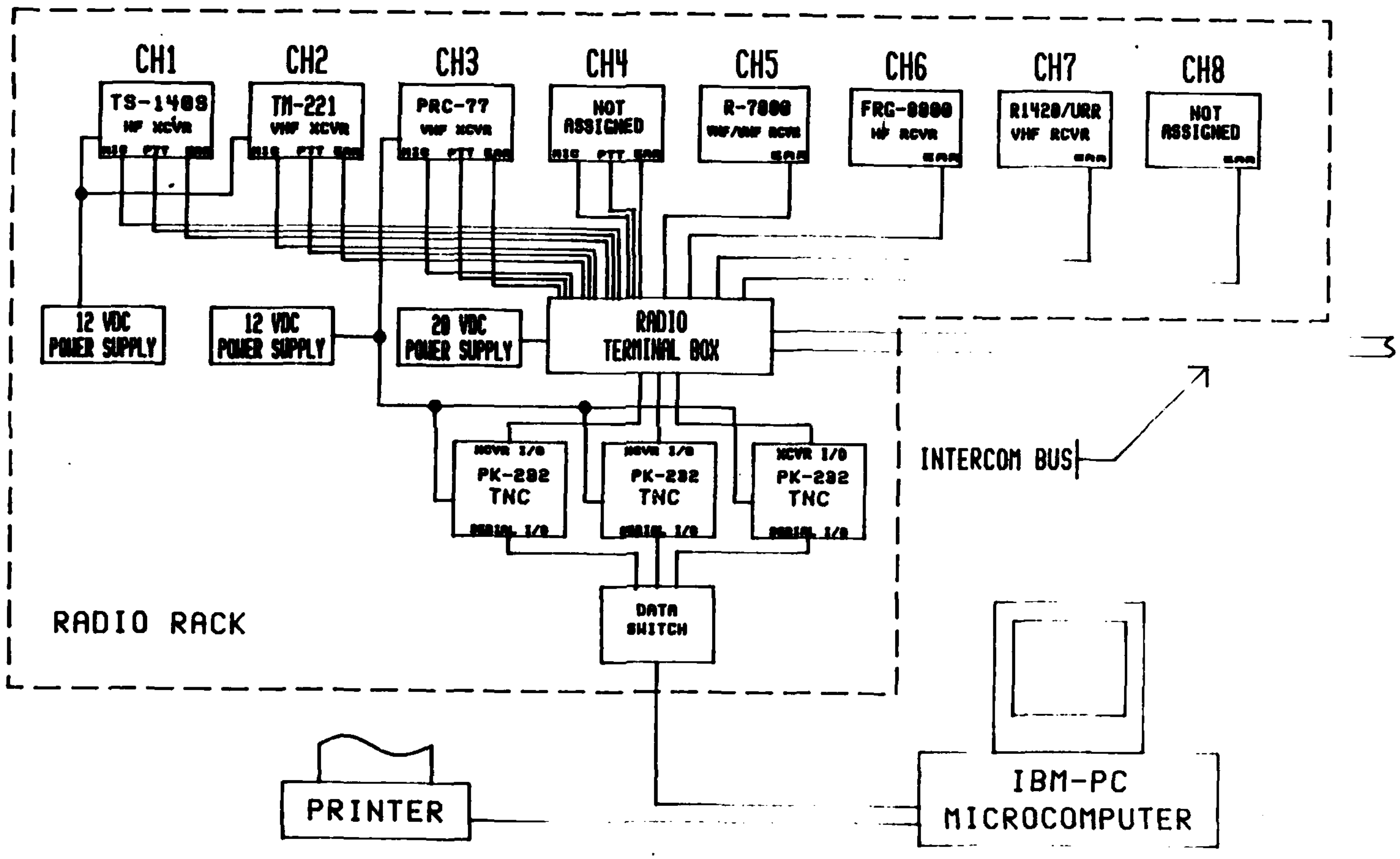

Figure 1. Radio subsystem.

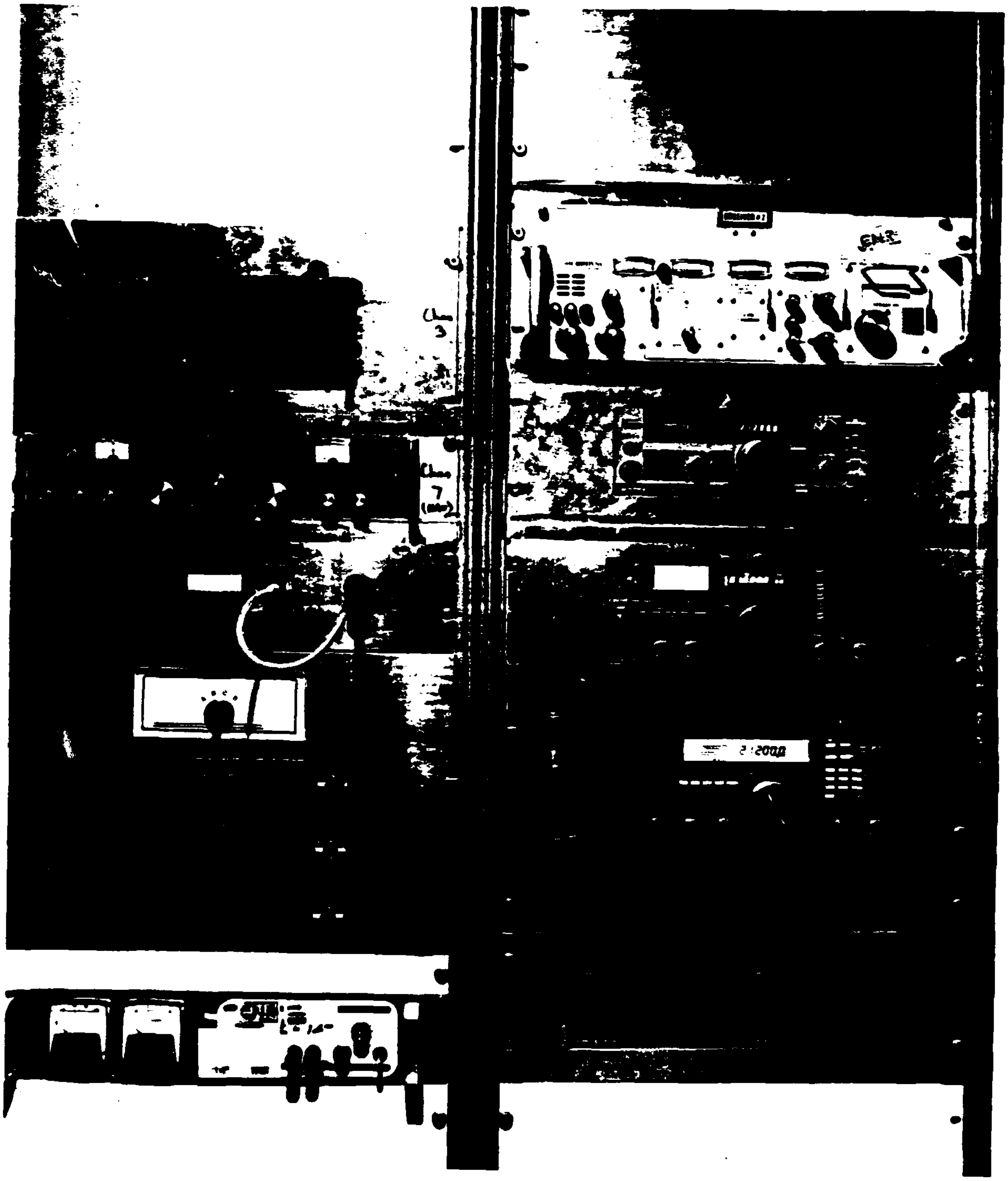

Figure 2. Radio rack.

Several modes of radio transmission modulation are supported. Continuous wave (CW) mode is provided for Morse Code transmissions. For voice and data transmissions, modulation modes provided are amplitude modulation (AM), upper sideband (USB) and lower sideband (LSB), carrier-suppressed AM, and frequency modulation (FM). Unit identification and basic specifications are as follows:

1. Radio Transceivers and Receivers

   a. HF transceiver (Kenwood TS-140S/Unit 1)

      Receiver: 50 KHz to 35 MHz coverage with CW, AM, USB/LSB, and FM reception modes.
      Transmitter: 100 watts maximum in 9 bands from 160 meters to 10 meters. Transmission modes as above.

   b. VHF transceiver (Kenwood TM-221A/Unit 2)

      Receiver: 138 MHz to 174 MHz, 14 memory channels and memory/band scanning capability, FM reception mode.
      Transmitter: 144 MHz to 148 MHz 45 watts output. Mode of transmission is FM.

   c. VHF transceiver (AN/PRC-77-77GY/Unit 3)

      Military manpack and vehicular-mount transceiver. Transmitter/Receiver: Frequency coverage in 930 channels with low band 30.00 to 52.95 MHz, and high band 53.00 MHz to 75.95 MHz. Transmission/Reception mode FM, output power 1.5 to 4.0 watts.

   d. VHF/UHF receiver (Icom R-7000/Unit 5)

      Receiver: All mode VHF/UHF coverage 25 MHz to 2 GHz with AM, FM, and USB/LSB reception modes. Includes capabilities for scanning of user-selected frequencies or frequency bands with a versatile system which can exclude idle channels. Also includes interface for computer control of receiver operation. This receiver is especially useful for radio communication intercept uses.

   e. HF receiver (Yeasu FRG-8800/Unit 6)

      Receiver: All mode general coverage 150 MHz to 29.999 MHz. Reception modes CW, AM, USB/LSB, and FM. Includes capabilities for scanning of user selected frequencies or frequency bands.

   f. VHF receiver (R-1420/URR/Unit 7)

      Receiver: Military type with CW, AM, and FM reception modes. Frequency coverage 30 MHz to 300 MHz in two bands. Circuitry is a hybrid design of vacuum tubes and transistors.

2. Data Controller (AEA PK-232)

Multimode radio modem and packet terminal node controller (TNC). Capable of operation in Morse Code, Baudot Teletype, ASCII Teletype, AMTOR, Weather Fax, and Packet (AX.25 protocol) transmission and reception. Possesses interfaces for transmit and receive radio equipment, and an RS-232 serial link for connection to the data terminal (microcomputer).

3. Radio Terminal Box

This is a locally-designed junction box which interfaces the transmit audio (microphone), transmit keying (push-to-talk), and receive radio (earphone) circuits into the Intercom Bus. This bus is a multiple line shared circuit which enables the interchange and monitoring of voice and data among radios, intercommunications sets, and the telephone system.

C. Internal Communications

Communications among the various operators of the C-Cube system is enabled by the use of the Intercommunication Control Set C-1611D/AIC. This is a military intercom set which provides amplifiers for a microphone and an earphone headset. It also has a versatile switching system which supports an Intercom Bus that permits very flexible communications to take place. Typically, a C-1611 set can monitor up to 8 signal sources (receivers, etc.), can operate up to 4 transmitters, can communicate on an intercom "party line" and can communicate on a "private line" to another pre-wired C-1611 set. Cabling among the C-1611 sets is via a multiconductor harness terminated in DB-37 connectors. Figure 3 shows the stations installed in the system. Figure 4 shows how the C-1611 is usually employed.

D. Wired Telephone Installation

Communications connection between the radios in the C-Cube Van and the commercial telephone system is enabled via a wired telephone connection. This is facilitated by the use of a C-1611 intercom unit and a "phone patch" unit. This phone patch is an MFJ model 624 which uses a hybrid-transformer design that provides two-way communications yet prevents the upset of the commercial telephone lines by the connection of the C-Cube van electronics. As shown in Figure 3, this system includes the microphone/earphone headset as well as a standard telephone set.

E. Communications Management Subsystem

The management of the communications is performed under the supervision of the System Commander by the Primary Operator who has at his disposal a C-1611 intercom set and a microcomputer. The intercom set is used to route voice signals from its source to its destination. The microcomputer is employed to receive data transmissions (CW, Packet, Fax, and the various Teletype modes), can archive a copy of a data transmission, and can relay the data on to its destination. An additional function of the microcomputer is to keep current an operations record (logbook) of the communications handled. This function is handled semiautomatically in the case of data transmissions, but operator inputs must be made for the voice communications. The microcomputer used is an IBM-PC which runs radio communications terminal

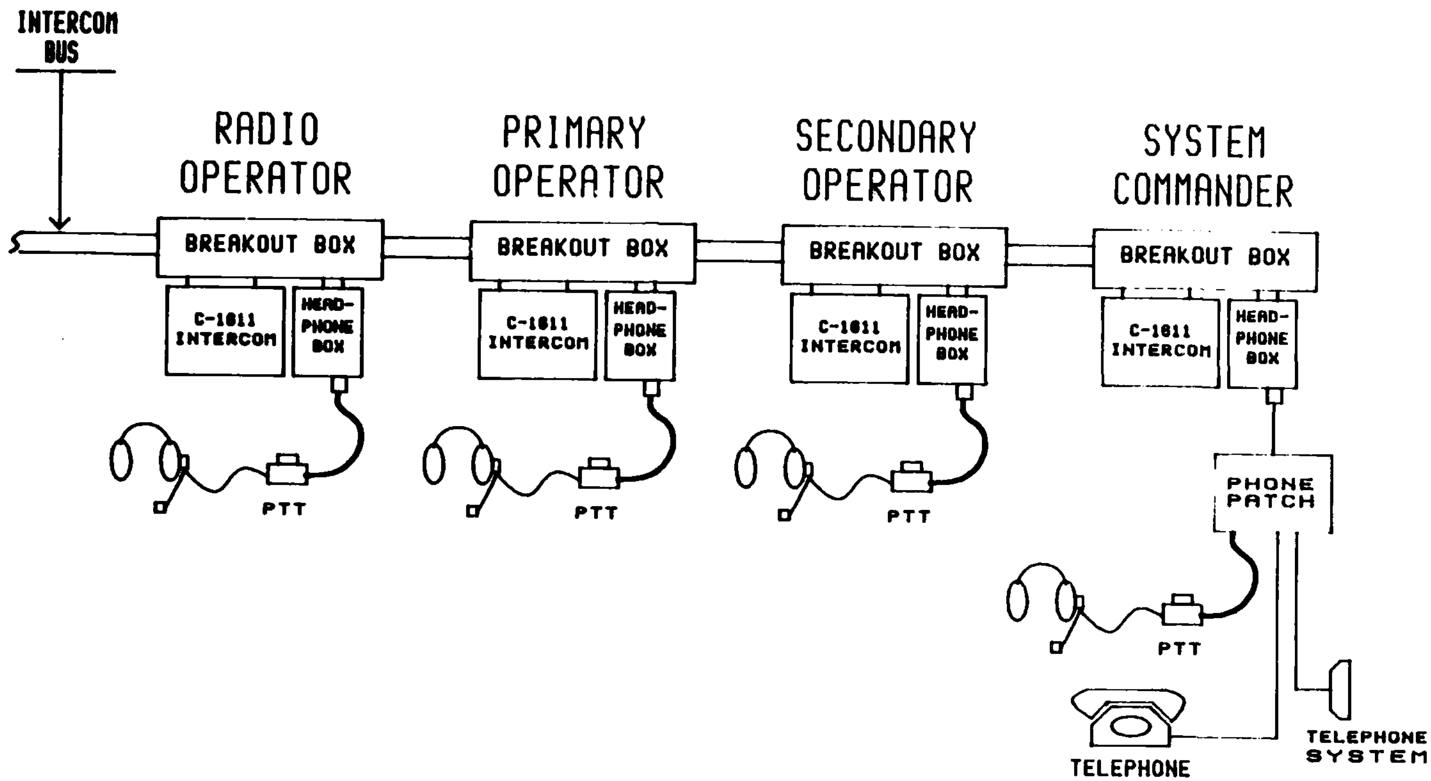

Figure 3. Intercom system.

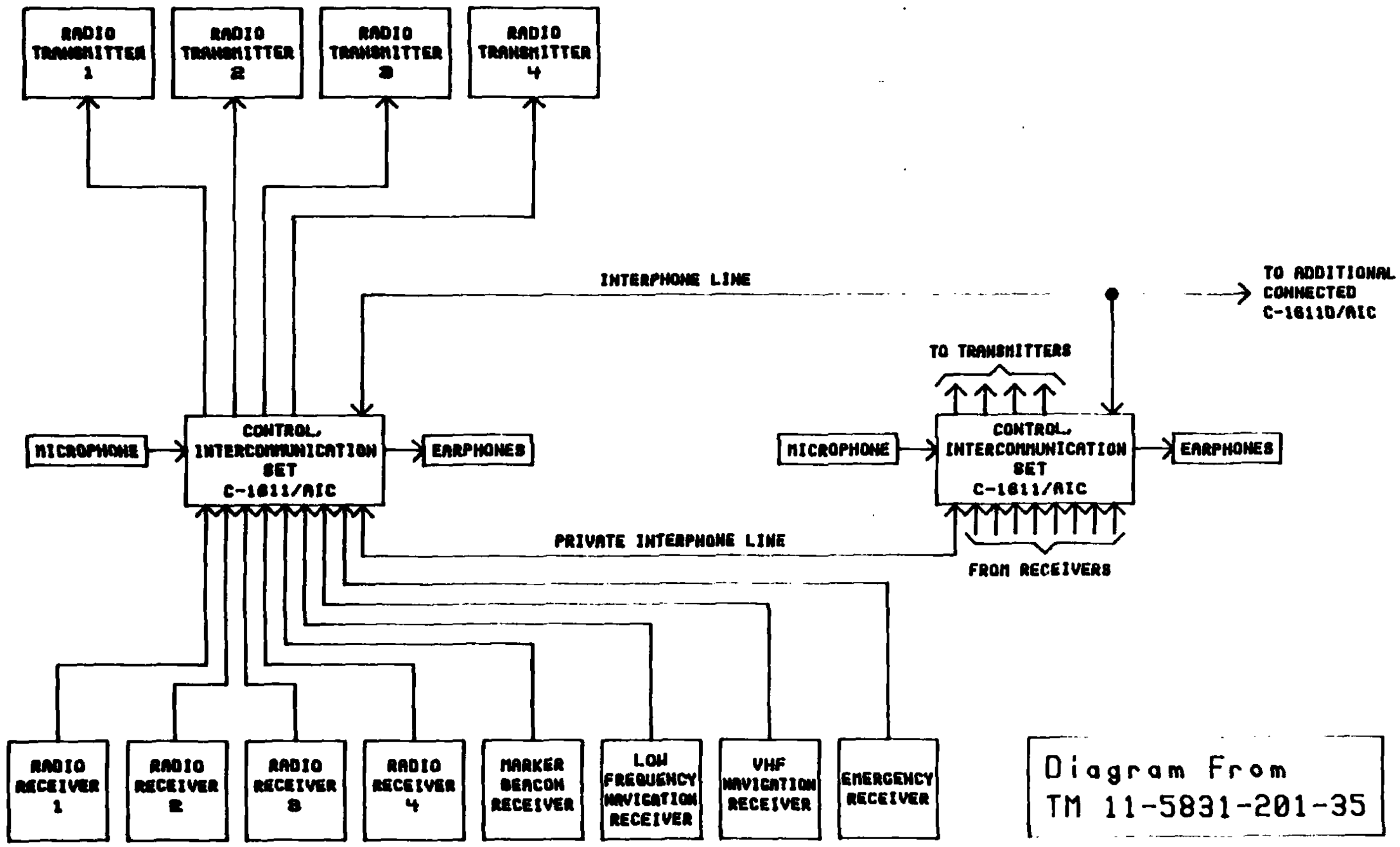

Figure 4. Intercom typical block diagram.

software that performs the above described operations. Peripheral equipment used with the microcomputer includes a printer for message and operations log print-out and with a graphics printing capability for print-out of images such as facsimile transmissions.

F. Power Subsystem

Power for the above subsystems is supplied from an external source (generator or commercial power) through a power line conditioner set. The trailer is wired to accept 208 volts, split three-phase, three-wire power input. There are no loads in the trailer which require three-phase power and (if modifications are made in the future) effort should be made to insure that no requirement for such is generated, it being desirable to avoid this restrictive power requirement. Several of the radios and other equipment operate from either 12 or 24 volt DC vehicular power. AC line operated power supplies are used to supply these DC voltages with the option of a modest amount of storage battery backup. For the case of critical AC operated loads (microcomputer, etc.) an uninterruptable power supply (UPS) with moderate storage battery capacity may be used. Grounding is of the single-point method where signal returns and power returns are kept separate and brought to a central ground point. This ground point should be connected to an earth ground when the C-Cube van is operating on-site.

G. Antennas

There are several antennas required to enable the proper and efficient operation of this C-Cube van over its full frequency range of 50 KHz to 2 GHz. These antennas are all van roof-mounted and they are classified into frequency bands as follows:

1. LF and MF bands (30 KHz to 3 MHz)

There is no current requirement to transmit in these frequency bands. If such a requirement develops, antennas will be locally designed and developed for this purpose. For reception, partial coverage is afforded by the "short dipole" antenna described in the next paragraph.

2. HF band (3 MHz to 30 MHz)

This band is covered by two antennas of different types. The first antenna is an untuned broadband "short dipole" which is used for reception coverage over the 150 KHz to 30 MHz range using the HF receiver (FRG-8800). This simple wire dipole has its feedpoint above the center of one edge of the van roof with the dipole wires stretched to points above the front and rear corners of the opposite side of the van roof. The second antenna is a 40-meter mobile vertical antenna. This antenna is used for transmit and receive operations using the HF transceiver (TS-140s).

3. VHF band (30 MHz to 300 MHz)

Three antennas are used to cover this frequency span. The first is a 6-meter mobile vertical antenna which is used for transmission and reception operations using the low VHF transceiver (AN/PRC-77-77GY). The second, a 2-meter vertical antenna, is used for transmit and receive operations using the high VHF transceiver (TM-221A). The third is a drooped-radial groundplane antenna which is for reception using the VHF receiver (R-1420/URR).

4. UHF band (300 MHz to 3 GHz)

One broadband antenna is used for this coverage. This is a hybrid vertical stub and discone antenna which provides for reception operations up to 2 GHz using the UHF receiver (R-7000).

H. Design of Crew Positions

The crew positions are System Commander, Primary Operator, Secondary Operator, and Radio Operator. Figure 5 is a photograph which shows the positions of the Radio Operator and the Primary Operator. The photograph of Figure 6 shows the positions of the Secondary Operator and the System Commander. These positions are described in detail below.

1. System Commander

The System Commander is responsible for the effective and efficient operation of the C-Cube van and its communications function. This entails administrative and management functions. To this end, this position is fitted with a desk which provides a drawer for files and a worktop large enough for working with several files or charts at once. A telephone set (equipped with the phone patch) is provided for communications with the headquarters of the unit to which this van is attached. The intercom set which is mounted at this position is fitted with the Hot Mike switch. This switch provides simultaneously for the giving of commands and receipt of responses via a commander-controlled party-line connection of the Intercom Bus. This intercom unit is also wired via the Private Interphone Line to the Radio Operator for the communication of the frequent frequency-change commands expected without disturbing the other operators who would be busy handling communications traffic.

2. Primary Operator

The Primary Operator is responsible for the maintenance of the communications log and the non-voice communications. If the volume of voice messages to be handled is excessive, this operator will also handle voice communications. The Primary Operator is also responsible for the operation and maintenance of the microcomputer and its peripherals. The operating position is at a fixed bench which is equipped with a standard intercom unit. At this position also is the microcomputer (mounted vertically below the bench) and the CRT monitor, keyboard, and printer. Operations at this position would be to follow a set schedule of contacts (such as the downloading of weather satellite photographs at certain times) and the reception, generation, and relay of digital messages on both a scheduled and an as-required basis.

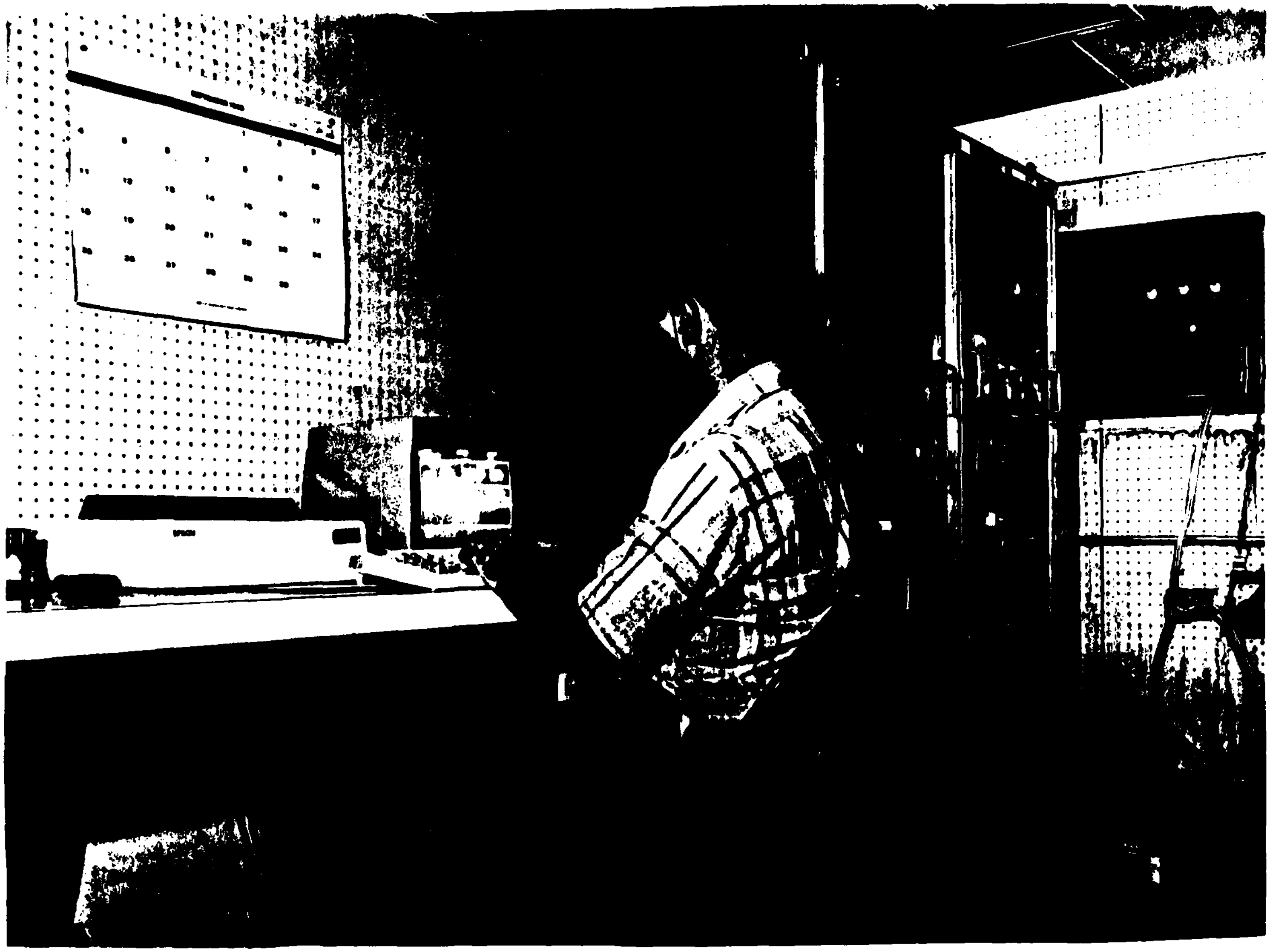

Figure 5. Primary and radio operator's positions.

Figure 6. System Commander's and secondary operator's positions.

3. The Secondary Operator is responsible for all voice communication operations. The operating position is at the above fixed bench to the left of the Primary Operator's position and is fitted with a standard intercom unit. The operator's responsibilities would be to receive, generate, and relay voice messages on both a scheduled and an as-required basis.

4. Radio Operator

The Radio Operator is responsible for the operation and maintenance of all primary communications equipment. This equipment includes all radio receivers and transceivers, antennas and mounts, radio-frequency feed-lines, intercommunication system, data modems (TNC) and data switching, and Radio Rack systems such as power supplies and AC power. During normal operations, the System Commander will communicate to the Radio Operator via the intercom unit on the Private Interphone Line any changes to the regularly-scheduled frequency and mode settings for the receivers and transceivers. The Radio Operator will make such settings and monitor the equipment's proper operation and make any adjustments or repairs as may be required to maintain proper system function. The Radio Operator's position is at the Radio Rack and a fold-away work surface and standard intercom unit wired for the Private Interphone Line is fitted to the trailer end-wall at the Radio Operator's right hand.

IV. SYSTEM DESIGN AND CONSTRUCTION

A. Functional Layout

The system functional layout is shown in Figures 1 and 3. The dashed line in Figure 1 denotes the Radio Rack which both shields the enclosed equipment and controls the AC power. The Intercom Bus and computer cable are both shielded with the bus passing through half-inch conduit to further protect the system. Central to the system is the Radio Terminal Box, which serves as an interface between the radios, Intercom Bus, and the computer. The Intercom Bus connects the four C-1611 D intercommunication sets such that communication is possible for each operator over the intercom or with any radio. Two operator stations connected with a private intercom line are reserved for the System Commander and the Radio Operator.

B. Radio Rack

The radio rack as assembled is shown in Figure 2. The rack itself is a steel structure, aluminum panel, dual-bay console for a HP2100 computer system. The AC power control was modified with the inclusion of two extreme isolation transformers between the power control and the 115 volt power strips for each bay. These transformers, which were mounted directly to the rack's bottom plate, served as power filters for the system. Two 8-inch muffin fans, which cooled the rack interior, were fitted with wire-mesh filters for shielding, while the ventilation ports of the rack were shielded with brass screen.

C. Radio Terminal Box (RTB) Interconnections

The radios, intercom system, and TNC's were interfaced within a steel box equipped with a shielded, hinged lid. A fiberboard grid was mounted within the box and was used to mount two double-row, 14-position barrier strips and three 12-position terminal blocks. All lines coming to or from the box were tied to one of the two barrier strips by looping the wire around the appropriate screw of the barrier strip.

Five- and three-pin rectangular flange female jacks (types D5F and D3F, 4 each) were mounted in two rows along one side of the RTB and shared the same ground and shield lines. The associated male cord plugs (types A5M and A3M) were attached to shielded twisted-pair cables which connected the audio lines of the radios. The 5-pin connections also included the PTT lines of the XCVR's. All audio lines from the jacks were soldered to the terminal block assembly before going to the barrier strips. This allowed later inclusion of potentiometers on lines which needed attenuation due to excessive audio levels or noise.

A 25-pin, D-subminiature female connector (type DB-25S) with a 25-wire pigtail was mounted on the side of the RTB and provided connection between the radios and TNC's. The desired lines of the pigtail were then connected to the appropriate audio and PTT positions of the barrier strips. Six custom TNC cables were soldered to a 25-pin, D-subminiature male connector (DB-25P) to complete the TNC-Radio interface. This last cable end was secured with shrink tape and electrical tape to both strengthen and consolidate the assembly as a single fixture. The output of each TNC to the computer was then patched through the data switch via shielded 9-wire cables with DB-25 connectors (pins 1-8, 20). The common position of the data switch was then routed to a shielded DB-25P connector mounted on a back panel of the rack. A "Y" cable provided with the TNC's completed the connection to the computer and printer. A 50-contact miniature ribbon socket (Cinch, 57-40500) with a 28-wire pigtail was mounted on the front of the RTB for connection to the intercom system. The solid conductor wires matched those used in the bus system and were connected to the desired locations on the barrier strips. A short length of the 50-wire solid conductor bus line was attached at one end to a matching plug (Cinch, 57-30500) for connection to the RTB, and at the other end to a shielded 36-contact miniature ribbon socket (Cinch, 57-40360) mounted on a rear panel of the rack. This cable was shielded with braid which was secured with shrink tape and electrical tape to the cable ends. A matching plug (Cinch, 57-30360) for the panel connector was attached to the intercom system bus for connection to the rack. The 28-volt power supply was attached to the RTB via a shielded twisted-pair cable with a Beau P-3303 socket and plug connector set. Because some of the equipment had the audio common and ground lines internally tied to the chassis, the power return, audio common, and shield lines within the RTB were tied together and routed to the chassis of the RTB to minimize ground loops.

D. Intercom System Installation

The intercom system consisted of four stations with C-1611 D intercommunications sets and the interface to the radio rack. A bus line with 28 active lines was required to fully incorporate all of the C-1611 features. In addition, the C-1611 control switches and audio outputs required 9 lines from the C-1611. As mentioned above, the connection of the 28-wire bus line to the RTB was made to the rack with a 36-contact ribbon plug (Cinch, 30360). This connector was attached to a short length of bus line which passed through half-inch flexible conduit. The free end of this cable was attached to a pull box (shielded with aluminum tape) mounted on the van wall behind the radio rack. This facilitated moving the rack away from the wall when maintenance was required in the rear.

With the exception of the rack connection, the bus line was housed within half-inch narrow-walled conduit which served to both shield and support the system. The conduit was mounted to the van walls using offset conduit brackets. Die cast utility cabinets (Bud CU-347) placed at the station locations were connected together and to the pull box with the conduit. These cabinets served as breakout boxes for the intercommunication sets. A second set of utility cabinets (Bud CU-234) was used to house the control and audio output lines of the C-1611 sets.

One side of each CU-234 box was machined to allow mounting of a DB-25P connector for the connection of the control lines from the C-1611. The control switches and audio jacks were mounted on the opposite side of each box and included the following: two each one-eighth inch stereo jacks for connection of the headsets, one DPDT momentary contact switch for the PTT control, and a DPDT toggle switch and indicator light for the command station Hot Mike function. These were wired to the DB-25P connector with solid conductor wire (switches normally open). The control box lids were then mounted using the provided hardware.

Holes were machined in the CU-347 lids to allow mounting of the C-1611 set and the control box while maintaining access to their connectors. The C-1611 was mounted using its rear panel screws, while the control box was mounted using the 4-40 hardware which attached the DB-25P connector. Pigtails for the C-1611 sets were then assembled using short lengths of bus line, a DB-37S connector for the C-1611, and a DB-25S connector for the control box. All 37 lines were first soldered to the DB-37S connector. The free ends of the control and audio output lines of the C-1611 were attached to the DB-25S connector. Two additional connections to the DB-25S connector were made to the ground and 28-volt power lines for added versatility in the control boxes. Connection to the bus line was made within the CU-347 breakout boxes and within the pull box. Two single-row, 14-position barrier strips were mounted in the breakout boxes parallel to the main axis. The mounting screws (6 x 1 inch panhead) also attached the breakout boxes to the van wall. Lengths of the 50-wire bus line were cut to pass through each section of conduit with approximately one foot extra length at each end. The outer insulation was then stripped and the 28 color coded wires for the active lines were selected. Beginning with the near end of each barrier strip, the appropriate wires were cut to fit, stripped, and twisted around the desired screws using hemostats. One side of the breakout box was finished before beginning on the second side, resulting in a neat and compact bed of wiring along the bottom of the box. Lastly, the 28 bus lines of the C-1611 pigtail were "twist-connected" to the desired barrier strip positions and all screws were tightened. The pigtail connectors were then attached to the C-1611 and control box ports on the breakout box lid, and the lid was mounted to the box with the provided hardware. The "tee" connection within the pull box was made using insulated buttlugs.

V. SYSTEM OPERATION

A. Intercom Set Operation

The intercom set controls and connections are shown in Figure 7. The intercom light and hot-mike switch are unique to the System Commander's station.

1. Intercom Operation

When S1 is set to INT (intercom), the operator's headset is connected to the system intercom line. The PTT switch operates as a crew station talk switch, automatically connecting all other stations to the intercom line and activating the commander's intercom light. Any operator with S1 set to intercom may talk over the intercom by depressing the PTT switch.

2. Hot-Mike Operation

For the System Commander's station, the hot-mike switch also connects all stations to the intercom line and activates the intercom switch. The System Commander's microphone is automatically connected to the intercom line, while PTT operation is required for all other stations. NOTE: The other operators do NOT have to have S1 set to intercom to talk during hot-mike operation.

3. Private Line

A private intercom line connects the System Commander's and Radio Operator's stations. Setting S1 to PVT connects the headsets of these operators to the private line. PTT operation is not required.

4. Monitoring Operations

Selection of switches S2-S6 allows monitoring of any number of the transceivers (XCVR's) and/or receivers (RCVR's). Switches S2-S5 select the receiver section of the XCVR's, while S6 (NAV) simultaneously selects three RCVR's associated with navigation (channels 5-7). (The output of channel 8, if used, is continuously applied to each set of headphones.) Selection of switch S7 applies the output of any monitored channels to the intercom line. An alternative way to monitor a single XCVR is described in the next section.

5. Transmission Operations

Transmission operation is accomplished by selecting a XCVR (1-4) with S1. This connects the output of the selected XCVR to the operator's headphones. Depression of the PTT switch then keys the XCVR and activates the operator's microphone for voice transmission. Direct message relay from one RCVR/XCVR to a different XCVR may be accomplished by connecting the output (headphone connection) of the receiving station to the input (microphone connection) of the transmitting station and depressing the PTT switch. Care should be taken to insure the audio level of the receiving station does not overdrive the transmitting station or XCVR.

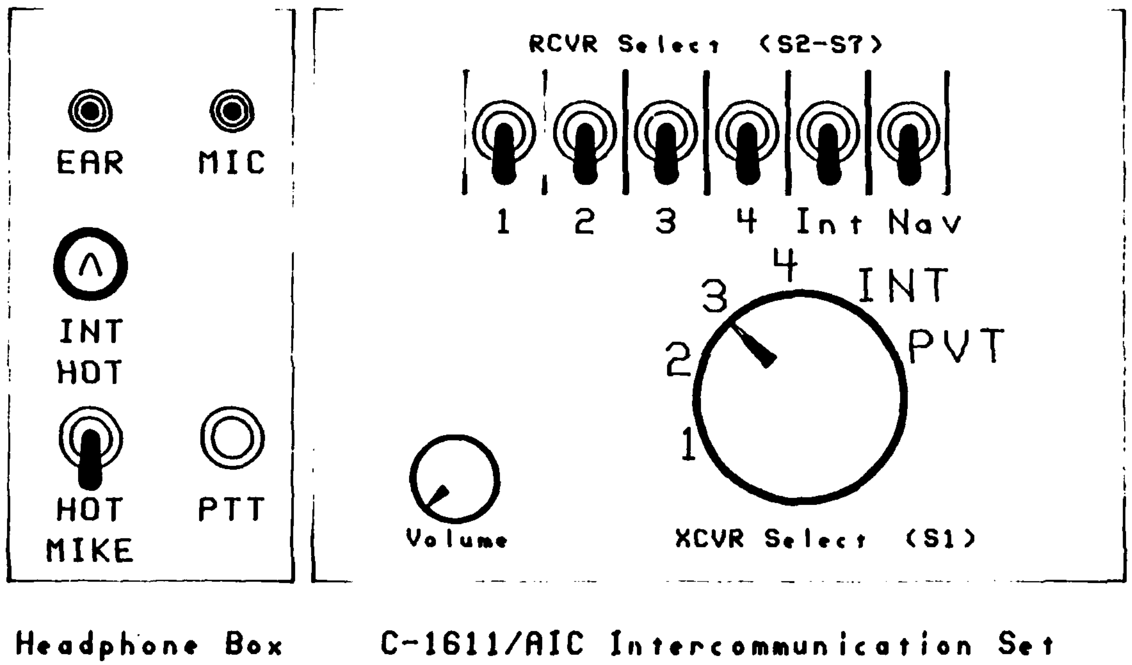

Figure 7. Intercom station set.

B. Radio Set Operation

1. Power Supplies

The radio set rack face is shown in Figure 2. Power is applied to all equipment (including the intercom sets, but not the microcomputer) by the rack power switch in the upper right-hand corner. The PS-430's supply 13.8v to the TM-221A and TS-140S (left-hand PS-430), and to the PRC-77 and all three TNC's (right-hand PS-430). The TC-32-10 supplies 28v to the bus line for intercom set operation. All other equipment is connected to the 115v power strips of the Radio Rack. The microcomputer is connected directly to the van's 115v power and is turned on by its own power switch.

2. Frequency Selection

A tuning dial selects the transmission/reception frequencies on all radios. In addition, the PRC-77 and R-1420-URR radios have band-selection switches on the front panels. Alternatively, the TS-140S, R7000, and FRG-8800 allow keypad entry of desired frequencies. These latter radios, along with the TM-221A, also have various possible scanning modes of operation. The operator is referred to the manual supplied with each radio.

3. Volume Control

The output of each radio is adjusted as follows: After tuning the radio to a strong incoming signal (preferably a local voice station), the radio is monitored over one of the intercom sets. With the intercom volume setting at maximum (fully clockwise), the radio volume control is adjusted until the output at the headphones is just above a comfortable listening level. The volume at the headphones may then be adjusted to the desired level with the intercom set volume control. (NOTE: the volume of Channel 7 is independent of the intercom box volume control.) The audio of the navigational channels may be set so that one signal is more prominent than the others.

4. TNC Operation

Use of the TNC's for digital communications is accomplished as follows. The rack equipment (radio sets, TNC's, and power supplies) is first turned on and appropriate adjustments are made. The flexible disk containing the computer system software is inserted in the disk drive and the microcomputer is turned on with its power switch located at the rear of the upper side of the mounted computer cabinet. The system software disc is then replaced with the flexible disc containing the communications software. One of the TNC's is then selected with the data switch (position A, B, or C). (NOTE: If a TNC is not selected (position D) or if the selected TNC is not turned on, an error will occur when the microcomputer attempts to establish communications with the TNC.) The command "pp RETURN" is then entered, which starts the terminal program. At the log-on screen, the spacebar is pressed to connect the PC and the selected TNC. The terminal program then displays the main screen from which the desired mode of operation (Baudot, Amtor, packet, etc.) may be selected. Specific information for the program may be obtained from the user's guide, "PC-Pakratt Terminal Program". (NOTE: Help is available at any level of the program by pressing the function key "F1".) At this point (main screen displayed), a second TNC is selected with the data switch. The program is then ended by typing "x" or "q". The program is automatically reentered and communications established between the microcomputer and the second TNC by depressing the spacebar at the log-on screen. From the main screen, the above procedure is repeated to establish communications between the microcomputer and the third TNC. (NOTE: If an error occurs at any point during the initial connection procedure, the TNC's must all be turned off to clear their memories. After turning the TNC's back on and with the microcomputer at the DOS level of command, the above procedure may be repeated.)

After communications have been established between the microcomputer and each TNC, digital communication is possible over any of the connected radios with the exception of the 1100-AR telemetry receiver. However, care must be taken to ALWAYS have the terminal program at the main screen before changing the selection of a TNC. This avoids crashing the terminal program, which would require reinitializing the entire system as noted above. Each TNC may access two radios. The present configuration is listed below in Table 1.

TABLE 1. TNC/Radio Selection

Data Switch Position	TNC Radio Selection	Selected Channel/Radio
A	1	1 / TS-140S
A	2	None
B	1	2 / TM-221A
B	2	None
C	1	3 / PRC-77
C	2	None

VI. CHECKOUT AND MODIFICATIONS

After the system was fully assembled and tests of individual subsystems indicated that no major faults were present, the system was operated in a mode to simulate full expected operation. In this checkout test, the receivers and transceivers were exercised by the individual operators in a variety of modes and frequencies. Transmission tests were made with the aid of other radio operators' signal reports.

It was found that a radio frequency feedback existed in the system. This was partially traced to the cables connecting the transceivers to the Radio Terminal Box. The audio signal lines for all radios were then bypassed with 0.001 microfarad capacitors and potentiometers were placed in the input lines to the transceivers. After adjusting the transceiver input levels with the potentiometers, the feedback was reduced to acceptable levels. The remaining feedback was believed to originate from crosstalk between the bus lines, which could effectively be eliminated by the use of a bus line with individually shielded wires. An alternating-current hum and "white-noise" existed within the system which was diminished to acceptable levels by disconnecting the ventilation fans. Since the Radio Rack is relatively large and well ventilated, there is no cooling problem anticipated in doing this.

VII. CONCLUSIONS

After the modifications as described above were performed, the C-Cube van was used as intended in support of a short testing sequence. During this period of operation, it performed its function with only minor problems. Most anomalies were found to stem from the complexity of the radio sets themselves and the relatively little experience of the operators with these particular units. The only hardware problem during the operation period was a broken wire in the Radio Terminal Box which prevented TNC-B from receiving packet transmissions. A condition exists within the intercommunications system which increases the noise level in the transmitted audio to higher values than desirable, although effective communications is readily conducted in spite of this. Apart from upgrading the busline with individually shielded lines, some effort will be expended to isolate the source of this noise and to eliminate or suppress it. The C-Cube van performed its intended function adequately and without major problems. This van provides a very flexible and extraordinarily capable communications hub for a wide variety of communications modes and frequencies and is a very valuable asset to any organization concerned with conducting radio communications.

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